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SPECIES OF THE FORAMINIFERAL FAMILY CAMERINIDAE IN THE TERTIARY AND CRETACEOUS OF MEXICO

By R. Wright Barker

During my work as micropaleontologist in Mexico, I have met with many species of Camerinidae, but in many cases, owing to inadequate literature available on the American species of the family, I have deferred identification of them. During the past few years this has resulted in the accumulation of many species with only tentative identifications and in many manuscript names of species believed to be new.

Recently it became possible to carry out research on the collection, and I made and photographed large numbers of sections. I wish to express my thanks to the Compañia Mexicana de Petroleo "El Aquila," S. A., and to the Bataafsche Petroleum Maatschappij for permission to publish material that originally formed part of confidential reports; and also to numerous individuals from whom help and advice were received. Among these must be mentioned especially Thomas F. Grimsdale, who assisted in sectioning and photographing the specimens, and Dr. T. Wayland Vaughan, who gave helpful criticism and supplied comparative material. Mrs. R. H. Palmer furnished valuable samples from Cuba; Dr. Lloyd G. Henbest kindly sent topotype material from the United States National Museum; and J. B. Garrett sent further specimens. To all these workers I am especially grateful, as correctly named material is essential in the study of any of the so-called "larger Foraminifera," particularly the Camerinidae, which do not lend themselves to detailed diagnosis as

do most of the other groups, and moreover they have frequently suffered in the past from very inadequate descriptions and figures.

STRATIGRAPHY

John M. Muir (1936) has recently published an excellent account of the stratigraphy of the area in which the present collections were made, and he clearly differentiates the various horizons. I have been accustomed, in common with many workers in Mexico, to a slightly different nomenclature, such as Alazan in place of Huasteca formation, Cole's Guayabal in place of ver Wiebe's Tempoal, and Velasco rather than Tamesi. Though there is little doubt as to the soundness of Muir's reasons for changing the nomenclature, both systems are given in the present account since the ages of the beds containing the species described were determined by means of the smaller Foraminifera as described by Nuttall (1932) in his account of the Upper and Lower Alazan and by W. Storrs Cole (1927, 1928) in his papers on the Chapapote and Guayabal. As there is some doubt as to the exact equivalence of the Huasteca to the Alazan as understood by Nuttall and also a possibility that the Guayabal of Cole represents a higher horizon than ver Wiebe's Tempoal (as exposed at the type localities of these formations), it has been thought better to give the older nomenclature and, in parentheses, what is considered to be the equivalent horizon of Muir.

The nomenclature alternative to that of Muir may be found in a recent publication of the writer (Barker, 1936).

PREVIOUS PUBLISHED WORK

Beginning with Cushman's monograph, "American Species of *Operculina* and *Heterostegina*" in 1921, a large number of species referred to *Operculina* and *Nummulites* have been described from the New World, though it had long been denied that true *Nummulites* existed there. The greater number of species have been contributed by Cushman, the elder and younger Rutten, Willard Berry, Mrs. Palmer, W. Storrs Cole, Dr. Vaughan, and Gravell and Hanna. The species of both L. and M. G. Rutten are in general well described, with fairly adequate illustrations; those of Cushman are very incompletely described, and in many cases sections either are not illustrated or are so badly illustrated as to be of little value; the work of Willard Berry is similar to his work on the Peruvian species of *Lepidocyclina* and may be neglected in the present résumé. Of most importance is a recent account by Dr. T. Wayland Vaughan and W. Storrs Cole (1936) entitled "New Tertiary Foraminifera of the Genera *Operculina* and *Operculinoides* from North America

and the West Indies," in which some new Mexican forms, hitherto unpublished, are described and figured. I have traced 50 recognized species of the genera *Nummulites* (*Camerina*), *Operculinella*, and *Operculinoides* described from the Americas, but it is not considered necessary to list these here, beyond stating that careful comparison has been made in the case of all Mexican forms with those previously found in the New World.

CLASSIFICATION

The Camerinidae possess the most extensive literature of any group of Foraminifera, so it is not proposed to give here long bibliographic lists, but only the more important references to American species.

The question of nomenclature is a difficult one, the accepted custom being to follow d'Orbigny in allotting the various species to the genera *Nummulites* (*Camerina* of Bruguière), *Operculina*, and *Assilina*, with the addition of Yabe's genus *Operculinella* for such forms as appear intermediate between *Camerina* and *Operculina*.

The establishment of *Nummulites* or *Camerina* for completely involute forms with lateral spaces between successive laminae, *Operculina* for completely evolute forms, and *Assilina* for forms that are involute but lacking the lateral cavities, the laminae being thin and closely appressed, seems at first to be a simple and clearly defined system of classification. Unfortunately, a certain number of species commence with an involute spire and later open out becoming complanate and evolute. Such forms were included by d'Orbigny and by Brady (see classification of the Nummulinidae in the *Challenger* Report) in *Operculina*, since the definition clearly states that the early whorls may be more or less embracing. Yabe, however, preferred to take such forms out of *Operculina* into a new genus *Operculinella*, producing more confusion, as individual ideas as to the characters of the new genus seem to be greatly varied.

Furthermore, none of the genera satisfactorily fitted the majority of American species, which are thin, of few whorls, complanate, and nearly always completely involute, without lateral cavities. As a result species have been variously attributed to *Camerina*, *Nummulites*, *Assilina*, *Operculinella*, and *Operculina* according to the opinion of each individual author. In 1935 Hanzawa erected the genus *Operculinoides* for the American group of species mentioned above; he refers a number of species to the new genus, on the evidence of actual specimens and on the original figures (Hanzawa, 1935, pp. 16–19) but does not illustrate the new genus, and the description might well be amplified. The genotype is given as *Operculinoides willcoxii* (Heilprin), and most American species formerly considered to belong to *Operculina* are transferred to *Operculinoides*.

The classification of Hanzawa has been adopted by Vaughan and Cole (1936) in the description of a number of new species of *Operculinoides* from North and Central America and the West Indies, and it is also followed herein.

I am not yet convinced as to the advisability of splitting up the group into so many genera, as in all cases forms can be found intergrading from one so-called genus into another. Thus it is often impossible to state with certainty whether a species should be *Operculinella* or *Operculina*, *Operculinoides* or *Camerina*, or even *Operculinoides* or *Operculina* (as in the case of *Operculina tuberculata* Vaughan and Cole), thus leaving much to the discrimination and personal opinions of the individual workers. There is also the problem as to whether the law of priority should be followed for *Camerina*, or the custom of accepted usage involving the use of the term *Nummulites*, to which many of the older workers still adhere. In the present account *Camerina* has been used, in accordance with the classifications of Cushman and Galloway, and the question as to whether the various "genera" could be better considered as subgenera of *Camerina* and *Operculina* has been deferred. I am of the opinion that Hanzawa (1935) rightly abandoned Hofker's theory that all the genera are synonymous with *Camerina*, and until more work has been done on the evolution and phylogeny of the group it seems preferable to adhere to the accepted classification as modified by Hanzawa.

In addition to the genera mentioned above we have two new genera recently erected by Hanzawa (1937), namely *Paraspiroclypeus*, referred to the Camerinidae, and *Pellatispirella*, included with *Pellatispira* in a new family Pellatispiridae. As Hanzawa notes, *Pellatispira* was included by Umbgrove and by Galloway in the Camerinidae, though considered by Cushman as showing more affinities with the Calcarinidae. Hanzawa removes the genera *Pellatispira* and *Pellatispirella* from the Camerinidae on structure of the shell wall and peculiarities of the canal system.

The double nature of the walls, which is well exemplified by *Pellatispirella matleyi* (Vaughan) and most species of *Pellatispira*, is much less marked in *Pellatispirella antillea* Hanzawa and appears to be a variable character. The principal difference between the canal system in the Camerinidae and the Pellatispiridae appears to be the presence of "vertical canals" in the latter. Thus Hanzawa (1937, p. 114) remarks as follows: "Vertical canals are always found in the genera *Calcarina*, *Rotalia*, and *Elphidium*, especially in their umbonal regions, but never in *Camerina*, *Assilina*, *Operculina*, *Heterostegina*, and *Spiroclypeus*."

I am not wholly in agreement with this statement, since vertical canals are seen in transverse sections of *Camerina* figured by Hofker (1927, p. 58) and of *Heterostegina* (1927, pl. 35). Carpenter (1862) mentions the presence of canals in the pillars in *Camerina*, and Möbius (1880, pl. 13) has figured similar canals in *Heterostegina*. In addition I have obtained Canada-balsam preparations of *Camerina variolaria* (Lamarck) that show excellently developed vertical canals in the bosses of clear shell material in the umbonal area; *Heterostegina* also shows vertical canals, and in some sections the aperture is clearly seen to be multiple, along the base of the septa, as described for *Pellatispirella*. The vertical canals are, admittedly, never so well developed in typical Pellatispiridae, but the differences do not seem to me to justify the formation of a new family. The various members of the Camerinidae show wide variation in the form of the canal system, in some cases as great as that shown by *Pellatispirella* from typical *Camerina*, and for these reasons it is proposed that the Pellatispiridae be allowed to remain in the Camerinidae, as a subfamily. The new species *Camerina pellatispiroides* is looked upon as linking the Pellatispiridae with the Camerinidae, since its canal system is closer to the former than to the latter, though the aperture is typical of *Camerina* and there is no sign of the double nature of the walls described for *Pellatispirella*.

DESCRIPTION OF SPECIES

Family CAMERINIDAE Meek and Hayden, 1865

Genus OPERCULINOIDES Hanzawa, 1935

OPERCULINOIDES WILLCOXII (Heilprin)

PLATE 13, FIGURE 3; PLATE 16, FIGURE 1; PLATE 21, FIGURE 13

1882. *Nummulites willcoxii* HEILPRIN, Proc. Nat. Acad. Sci. Philadelphia, vol. 34, p. 191, figs. 1, 2; *ibid.*, vol. 36, pp. 321–322, figs. 1, 2, 1884.

1921. *Operculina willcoxii* (Heilprin) CUSHMAN, U. S. Geol. Surv. Prof. Paper 128–E, p. 129, pl. 20, figs. 9–11.

1928. *Operculinella willcoxii* (Heilprin) VAUGHAN, 19th Ann. Rep. Florida State Geol. Surv., p. 158.

1935. *Operculinoides willcoxii* (Heilprin) HANZAWA, Sci. Rep. Tôhoku Imp. Univ., ser. 2 (Geol.), vol. 18, no. 1, p. 18.

This species has recently been made the genotype of the new genus *Operculinoides* (see Hanzawa above). The Mexican specimens have been compared with specimens from the Gulf coast of the United States and seem essentially the same species. Their description is as follows:

Test large, very compressed, completely involute, the last whorl showing rather clearly on the exterior (after the fashion of *Assilina*). Sutures not clearly visible on the exterior. Diameter, average 5.3 mm,

with an observed maximum of 7.0 mm; thickness, up to 1.0 mm, with an average of between 0.8 and 0.9 mm.

Sections show the coiling to be regular, mature specimens showing 5 to 6 whorls with 37 or 38 chambers in the final one. The septa are thin and slightly sigmoid in shape, recurving sharply toward the periphery. Chambers numerous, rather long in proportion to their width. Transverse sections show that there is a tendency for the outer walls of succeeding coils to become closely appressed, without, however, becoming fused.

Plesiotypes.—U.S.N.M. nos. 497829 and 497830.

Other specimens.—U.S.N.M. nos. 497831 and 497832.

Occurrence.—Common in the Tantoyuca formation, Jackson Eocene.

OPERCULINOIDES NUMMULITIFORMIS (L. Rutten)

PLATE 17, FIGURE 5; PLATE 21, FIGURE 1

1928. *Operculina nummulitiformis* L. RUTTEN, Proc. Sect. Sci. Kon. Akad. Wetensch., Amsterdam, vol. 31, no. 9, p. 941, figs. 1–12.

1932. *Operculina nummulitiformis* L. Rutten, M. G. RUTTEN and VERMUNT, Proc. Sect. Sci. Kon. Akad. Wetensch., Amsterdam, vol. 35, no. 2, p. 239, pl. 1, figs. 7, 10; pl. 2, fig. 1. (Full synonymy given in this account.)

1937. *Operculinella nummulitiformis* (L. Rutten) VAUGHAN, *in* Sheppard's "The Geology of South-Western Ecuador," pp. 159–160, figs. 116 (1–3).

Mexican specimens identified as this species are described as follows:

Test of medium size, very compressed, completely involute. The sutures are strongly beaded and slightly raised, the test being a little thicker in proportion to diameter than in *O. prenummulitiformis.* Diameter, average 3.0 mm; thickness, average 0.5 mm.

Sections show numerous long narrow chambers, the test showing 3½ to 4½ whorls, with 28 to 33 chambers in the final whorl. The septa are rather irregular as shown in Rutten's original figures of *O. nummulitiformis.* The Mexican specimens differ from L. Rutten's original description in that they are slightly thicker (0.5 mm average compared with 0.35–0.45 mm) and from Rutten and Vermunt's description in having beaded sutures in place of a smooth surface. This latter difference may be due, perhaps, to state of preservation and to local variation, as the degree of beading is variable in specimens examined. In other respects the species are remarkably similar, and Rutten and Vermunt's figure (1932, pl. 2, fig. 1) leaves little doubt in my mind that the Mexican specimens should be referred to *O. nummulitiformis.* It seems doubtful whether Vaughan's Ecuadorian material should be referred to this species, since the specimens figured show a more rapidly opening spiral with fewer whorls and fewer chambers in the final whorl in proportion to the size of the

test than is shown in the figures of Rutten or Rutten and Vermunt. The latter authors place *O. atascaderensis* Berry and *O. peruviana* in the synonymy of *O. nummulitiformis*, with which I am in agreement. Thus we have a wide-ranging form occurring in the upper Eocene of Peru, Ecuador, Curaçao, and Mexico.

Plesiotypes.—U.S.N.M. no. 497834.

Other specimens.—U.S.N.M. no. 497833.

Occurrence (in Mexico).—Tantoyuca formation, Jackson Eocene.

OPERCULINOIDES PRENUMMULITIFORMIS, new species

PLATE 12, FIGURES 1, 2; PLATE 17, FIGURE 4; PLATE 21, FIGURE 2

Test of medium size, very compressed, completely involute, the last whorl somewhat thinner than the earlier coils. Sutures are slightly raised, rather limbate, and show a tendency to become beaded, especially toward the center of the test. Diameter, up to 4.0 mm, average 3.25 mm; average thickness, 0.5 mm.

Sections show the test to be composed of 3½ to nearly 4 whorls, with 22 to 27 chambers in the final whorl. The septa are numerous, thin, and uniformly curved throughout their length. The chambers are long and narrow and of even size and shape, in contrast to the irregularities shown by the closely allied form *O. nummulitiformis* (Rutten). Sections also reveal the presence of numerous supplementary or secondary apertures, irregularly distributed along the septa as illustrated by Carpenter ("secondary pores," 1862, p. 254, fig. 12). The exact significance of these has not yet been satisfactorily explained, but they may have been developed in the first place in connection with adaptation to such factors as food supply. As remarked under *O. jennyi*, the development of multiple apertures probably led at a later stage to formation of subsidiary chamberlets, such as are found in *Heterostegina* and *Spiroclypeus*.

Cotypes.—U.S.N.M. nos. 497835 and 497836.

Occurrence.—Guayabal (Tempoal) formation, Claiborne Eocene. Cotypes have been selected from Poza Rica Well no. 8, a further excellent suite of specimens being obtained from core samples of Mecatepec Well no. 6.

OPERCULINOIDES TUXPANENSIS (Thalmann)

PLATE 16, FIGURE 2; PLATE 17, FIGURE 2

1935. *Operculina tuxpanensis* THALMANN, Eclogae geol. Helvetiae, vol. 28, pp. 603–604, figs. a, b (Tuxpam formation, Mexico).

1936. *Operculinoides tuxpanicus* VAUGHAN and COLE, Proc. U. S. Nat. Mus., vol. 83, p. 494, pl. 37, figs. 4–9.

This form, which is of medium size, thin and compressed, and completely involute, is described by Thalmann as having a diameter of 3 to 4 mm; thickness 0.2 to 0.3 mm, and 3½ whorls with 28 to 32 chambers in the last whorl. This, according to Thalmann, is for the microspheric form, though from his figure this is not certain. The surface is smooth in all specimens examined.

Sections made from material collected by Thalmann, near his type locality (various outcrops along the Tuxpam River between Cobos and Tuxpam) show 3 to 3¼ whorls, with 20 to 24 chambers in the final whorl. The coiling is somewhat irregular; the sutures thin, a thick outer wall giving a thickened, rounded periphery; the chambers are numerous, long, and narrow.

Specimens from Biche Quarry, Nariva District, Trinidad, British West Indies (the Guaracara limestone), in the collection of T. F. Grimsdale, are considered to belong to this species. There seems to be no doubt that *Operculinoides tuxpanicus* Vaughan and Cole is a synonym of *Operculina tuxpanensis* Thalmann, though Thalmann undoubtedly had much better material than Vaughan. Various measurements are given below for comparison:

Species	Diameter	Thickness	Number of whorls	Number of chambers in final whorl
	Mm	*Mm*		
Operculina tuxpanensis Thalmann	3–4	0.2–0.3	3½	[1] 28–32
Specimens sectioned by the writer	2.5–3.0	0.3–0.4	3–3½	20–24
Operculinoides tuxpanicus Vaughan and Cole	1.7–3.2	0.3–0.5	3–3½	19–20

[1] Microspheric.

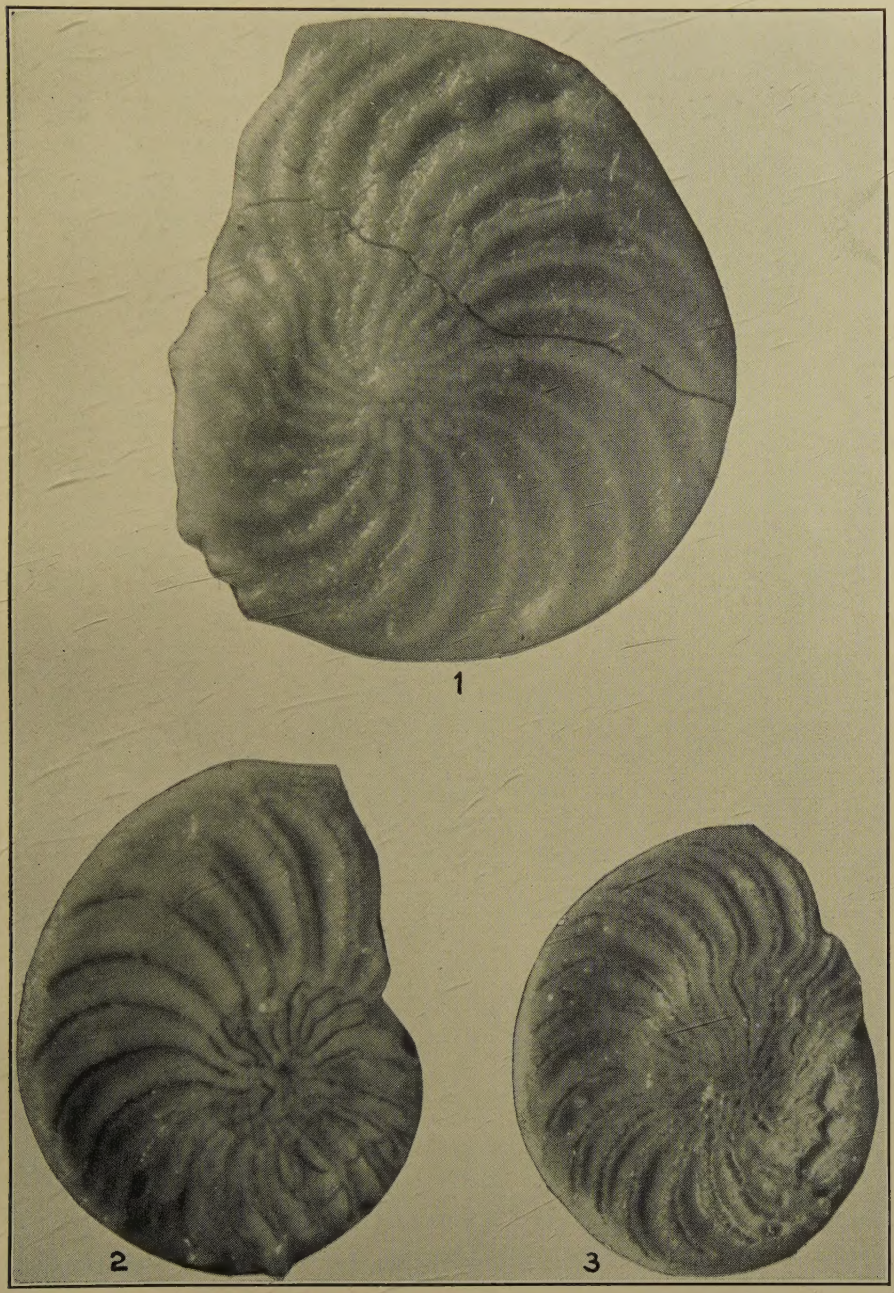
Plesiotypes.—U.S.N.M. no. 497838.
Topotypes (?).—U.S.N.M. no. 497837.
Occurrence.—Tuxpam formation, lower Miocene.

OPERCULINOIDES MUIRI, new species

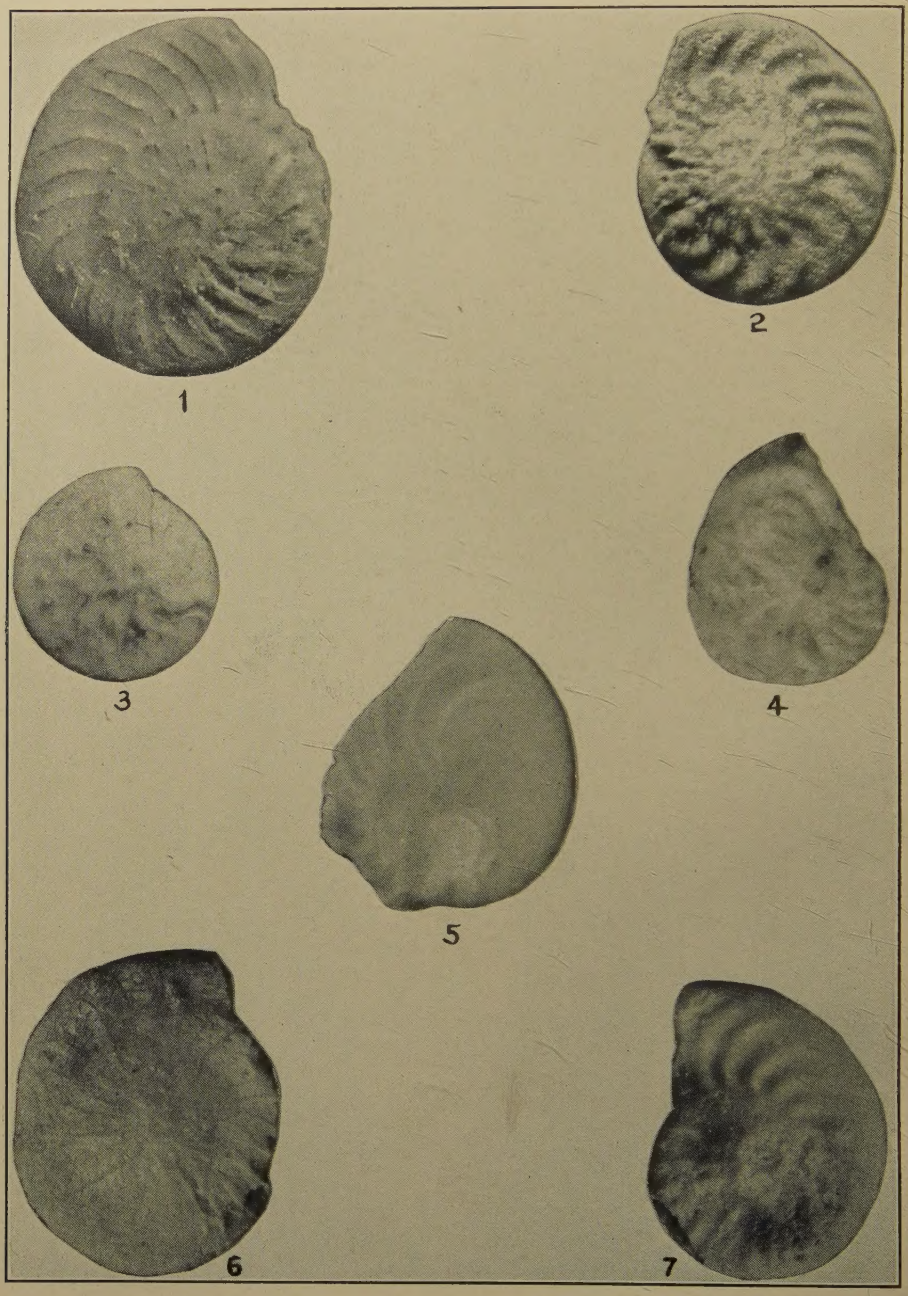
PLATE 14, FIGURE 4; PLATE 20, FIGURE 1; PLATE 22, FIGURE 1

Test small to medium in size, completely involute, lenticular and rather close-coiled, with a fairly well developed, rounded keel of clear shell material. Diameter, up to 3.0 mm (average for 10 specimens, 2.6 mm); thickness, 0.7 to 0.9 mm.

Median sections show regular, rather close coiling, with 4 to 4½ whorls, with 20 to 24 chambers in the final whorl. The sutures are slightly oblique, curving rather strongly as they approach the periphery. In transverse section the rather inflated lenticular form

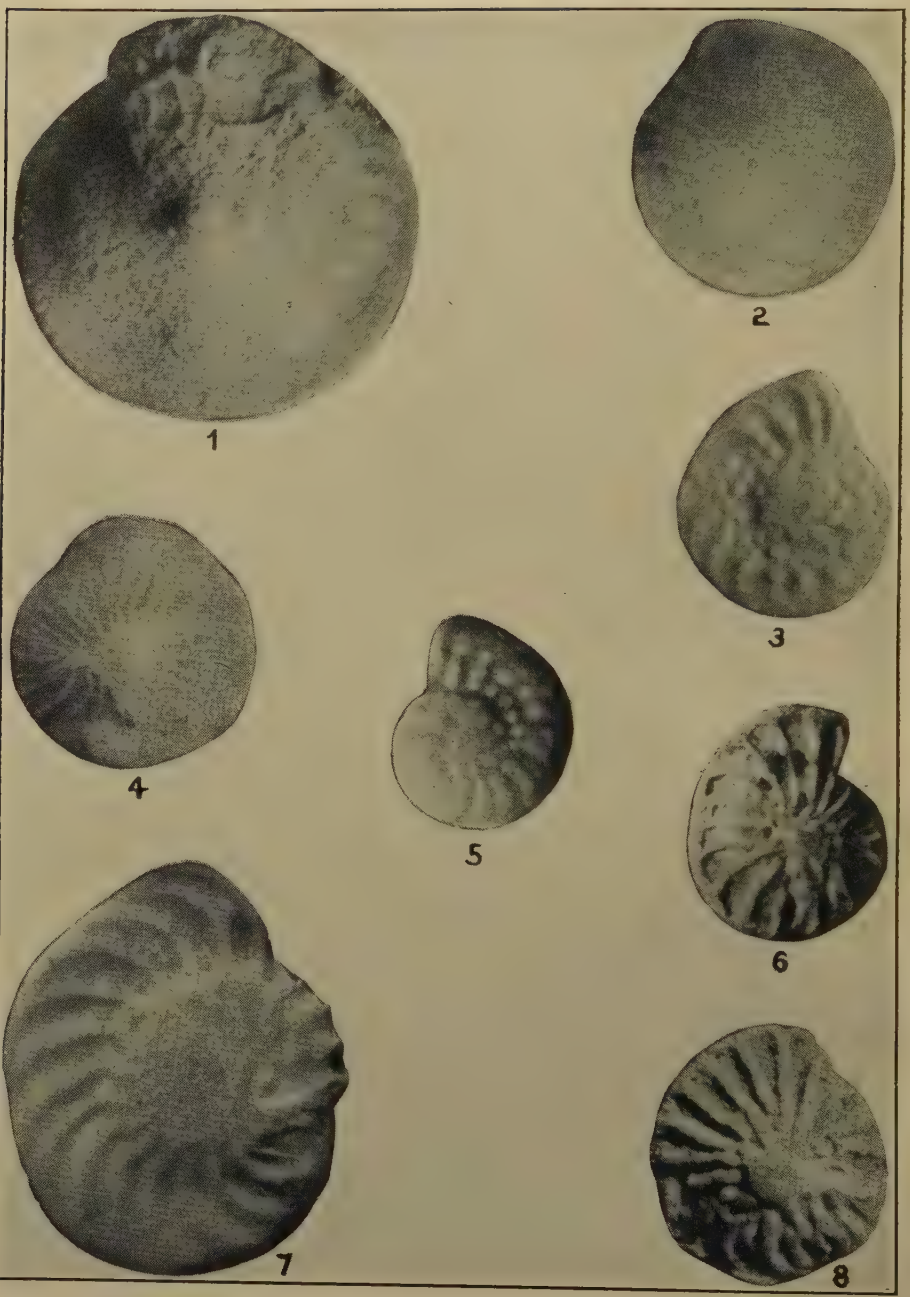


1, *Operculinoides oliveri* (Cushman), probably a topotype, from Guayabal beds, near Romance, Rio Moctezuma, Mexico; 2, 3, *O. vaughani* (Cushman), Guayabal beds, Guayabal, Tamatoco, Veracruz (type locality of W. S. Cole). ×15.



1, *Operculinoides prenummulitiformis*, new species, Guayabal formation, Poza Rica Well no. 8 near Coatzintla, Veracruz; 2, *O. prenummulitiformis*, Guayabal formation, collection E. Gevaerts no. 551, Zanatepec, Veracruz; 3, *Operculinoides* sp. B, Guayabal formation, near Tantoyuca, Veracruz, collection H. Rankin no. 277, Tantoyuca region; 4, *O. ocalanus* (Cushman) *minor*, new variety, Guayabal formation, collection P. von Schumacher no. 2589, east of Tempoal, Veracruz; 5, *O. ocalanus* (Cushman), Tantoyuca, Jackson Eocene, collection K. Goldschmid Pit no. 283, southeast of Tempoal; 6, *O. vicksburgensis* Vaughan and Cole, Alazan formation, collection E. Gevaerts no. 292, southern Miahuapam, Veracruz; 7, *O. jennyi*, new species, Guayabal formation, collection H. Meyer no. 1477, Santa Clara, southeast of Tantoyuca. ×15.

1, 2, *Camerina jacksonensis* Gravell and Hanna *globosa*, new variety, lower part of Tantoyuca formation, Jackson Eocene, collection H. Rankin no. 50, east of Tantoyuca, Veracruz; 3, *Operculinoides willcoxii* (Heilprin), Tantoyuca formation, Jackson Eocene, Tantoyuca type locality: Tantoyuca-Chopopo road, east of Tantoyuca; 4, *Camerina guayabalensis*, new species, Guayabal, Claiborne, from Mecatepec Well no. 5; 5, *C. moodybranchensis* Gravell and Hanna, Tantoyuca formation, well sample, Poza Rica no. 7; 6, *C. jacksonensis* Gravell and Hanna, Tantoyuca formation, Tantoyuca-Chopopo road, near Tantoyuca; 7, *C. vanderstoki* (Rutten and Vermunt), Guayabal formation, collection H. Meyer no. 1017, southern Chila Cortaza, east of Tantoyuca; 8, *Operculinoides palmarealensis*, new species, Alazan formation (Huasteca of Muir), lower Oligocene, Mecatepec Well no. 5, near Poza Rica, Veracruz. ×15.



1, 2, *Operculinoides antiguensis* Vaughan and Cole (fig. 1, microspheric form, Meson formation, below Tampico Country Club, Tampico, Tamaulipas; fig. 2, megalospheric form, Meson formation, near Bustos, Veracruz); 3, 5, *O. tuberculatus* (Vaughan and Cole), Tantoyuca formation, collection W. H. Hegwein no. 1559, near Tantoyuca, Veracruz; *O. muiri*, new species, Alazan formation, collection E. Gevaerts no. 269, southern Miahuapam, Veracruz; 6, 8, *O. catenula* (Cushman and Jarvis), lower part of Chicontepec, near Sabaneta, Veracruz, collection W. Tappolet no. 1908; 7, *O. jennyi*, new species, Guayabal formation (Tempoal of ver Wiebe and Muir), near Sabaneta, collection H. Jenny no. 1573. ×15.

of the test, the regular nature of the coiling, and the even development of the walls are well brought out (see pl. 22, fig. 1).

The species seems to be identical with an undescribed species observed in samples from the Byram marl of Byram, Miss. (for which the writer is indebted to Mrs. F. B. Plummer). The nearest described species seems to be *O. vicksburgensis* Vaughan and Cole, but *O. muiri* is considerably thicker than that species (0.7 to 0.9 mm as compared with 0.3 to 0.6 mm) and rather more closely coiled. Dr. T. Wayland Vaughan has examined the types and is of the opinion that the species is new. It has been named after the late John M. Muir, who contributed much toward the elucidation of the stratigraphy of the Tampico region, and whose recent death was felt very deeply by all connected with Mexican stratigraphy and petroleum geology.

Cotypes.—U.S.N.M. nos. 497839 and 497840.

Occurrence.—Lower Alazan (probably restricted to the lower part of Muir's Huasteca formation).

OPERCULINOIDES ANTIGUENSIS Vaughan and Cole

PLATE 14, FIGURES 1, 2; PLATE 16, FIGURE 3; PLATE 17, FIGURE 1; PLATE 21, FIGURES 10, 11

1936. *Operculinoides antiguensis* VAUGHAN and COLE, Proc. U. S. Nat. Mus., vol. 83, p. 492, pl. 38, figs. 7–10.

1937. *Camerina* sp. B THIADENS, Journ. Pal., vol. 11, p. 95, figs. 3B, 3D, pl. 15, fig. 3 (Oligocene, Cuba).

Test small to medium in size, completely involute, lenticular in cross section, with a rather acute periphery. Diameter (megalospheric form), average 2.4 mm, with a maximum observed of 2.8 mm; thickness, average 1.00 mm. The microspheric form (which is fairly plentiful in the Meson outcrops below the Tampico Country Club) is a little larger, averaging 3.5 mm in diameter.

The sutures, seen from the exterior, are radiating, lying flush with the surface of the test, showing as lines of clear shell material proceeding from a clear central mass. In general, sections show 4 whorls, regularly coiled, with a thick outer wall, the final whorl showing 23 to 26 chambers. Exceptional specimens may show 28 or 29 chambers in the last whorl.

The most marked characteristic of the species seen in median sections is the shape of the septa, which are straight and radial for a little more than half their length and then recurved at an abrupt angle toward the periphery (see figure). This character is well shown by Thiadens's *Camerina* sp. B (1937, pl. 15, fig. 3), and there seems little doubt that this should be referred to *O. antiguensis*.

Plesiotypes.—U.S.N.M. nos. 497841 and 497842.

Other specimens.—U.S.N.M. no. 497843.

Occurrence.—This species has been recorded only from the Meson formation, middle to upper Oligocene.

OPERCULINOIDES SEMMESI Vaughan and Cole

PLATE 19, FIGURES 1–6

1936. *Operculinoides semmesi* VAUGHAN and COLE, Proc. U. S. Nat. Mus., vol. 83, p. 491, pl. 37, figs. 10–13 and probably 14; pl. 38, figs. 1–4 and probably 5 and 6.

In early work I included *O. antiguensis* and *O. semmesi* in a single species, with a considerable range in variation, but Vaughan and Cole have separated slightly smaller specimens, with a thinner test and fewer chambers in the final whorl, as *O. semmesi.* This species is similar to *O. antiguensis* in general appearance, but, in large numbers of specimens seen by me, is generally smaller and thinner, though the range in diameter (1.75 to 2.8 mm) is almost the same for the two species. Thickness, 0.55 to 0.65 mm.

Sections show 3 to 3½ whorls, with 18 or 19 chambers in the final whorl. The septa show the same characteristic curvature as *O. antiguensis.* It is still thought that *O. semmesi* may be only a variety or a dwarf race of *O. antiguensis*, since both have the same range in Mexico and have not yet been found to occur in the same localities, suggesting that the differences may be due to local changes in environment.

Plesiotypes.—U.S.N.M. nos. 497844 and 497845.

Other specimens.—U.S.N.M. nos. 497846 and 497847.

Occurrence.—Believed to be restricted to the Meson formation.

OPERCULINOIDES PALMAREALENSIS, new species

PLATE 13, FIGURE 8; PLATE 18, FIGURE 1; PLATE 22, FIGURES 7, 8

Test small, stoutly lenticular, completely involute, with an acute periphery. The septa show as gently curved lines of clear shell material radiating from a large, clear central mass. Diameter, 1.8 to 2.2 mm; thickness, average 0.9 mm.

Sections show the septa to be sharply recurved, somewhat as in *Operculinoides antiguensis* and *O. semmesi*, but the curvature is not so abrupt, the coiling is less regular, and the test is consistently smaller and thicker in proportion to the diameter. Mature specimens usually show 4 whorls, with 18 to 20 chambers in the final whorl. The chambers are somewhat irregular in size and shape.

Cotypes.—U.S.N.M. nos. 497848–497850.

Occurrence.—Alazan formation (Huasteca formation of Muir), lower Oligocene. The description is based on cotypes from Mecatepec Well no. 5, Mecatepec, Veracruz.

OPERCULINOIDES JENNYI, new species

PLATE 12, FIGURE 7; PLATE 14, FIGURE 7; PLATE 17, FIGURE 3; PLATE 19, FIGURE 7; PLATE 21, FIGURE 9

This species was at first separated into two groups according to the degree of granulation of the sutures and the closeness of the coiling, but it is now believed that only one species is represented with a wide range of variation.

Test of medium size, compressed lenticular, completely involute, complanate to a variable extent. The sutures are frequently irregularly beaded, and the poles are sometimes covered with a thick tuberculate mass of shell material, which is part of the final whorl. The sutures are generally raised, and strongly curved near the periphery, which they join at a very oblique angle, as in figures given by Cushman (1921) for *O. ocalanus*. Diameter, up to 6.0 mm, averaging 3.8 mm for 20 specimens; thickness, 0.8 to 1.0 mm.

Sections show rather irregular coiling, a very thick outer wall, and a rapidly opening spiral of 2½ to 3½ whorls, with 18 to 28 chambers in the final whorl. Five sections selected to show the range of variation show the following characters:

Diameter	Number of whorls	Number of chambers in final whorl
Mm		
3.0	2.5	22
3.1	3	18
3.8	3	23
3.7	3.5	21
4.0	3.5	28

The species was at first considered to be a variety of *O. ocalanus* (Cushman), but careful comparison with material from the Ocala limestone and with figures recently published by Vaughan (1937), taken in conjunction with the discovery of *O. ocalanus* at a considerably higher horizon in Mexico, have led me to consider this as a distinct new species. Typical specimens of *O. ocalanus* show fewer chambers in the final whorl and in general a more rapidly opening spiral, though rare specimens of *O. jennyi* occur which show all the essential features of *O. ocalanus*.

An interesting character of this species is shown by transverse sections (see pl. 21, fig. 9). The spiral laminae show incipient subdivision, with splitting off of thin walls, giving lateral cavities suggestive of the lateral chambers of the Orbitoididae. This is a similar character to that shown by *Camerina chawneri* Palmer, which

has recently been made the genotype of a new genus, *Paraspiroclypeus*, by Hanzawa (1937, pp. 116–117). In *O. jennyi*, however, the subdivision is much less plainly marked, the species being considered intermediate between *Operculinoides* and *Paraspiroclypeus*, thus substantiating Hanzawa's theory of the relationship between the two genera.

A further point that may perhaps have some bearing on this is the presence of well-marked multiple apertures (seen in median sections) in *O. jennyi*. These have been figured by Carpenter as "secondary pores" (see also under *O. prenummulitiformis*) and may have led later to subdivision of the chambers into chamberlets as seen in *Spiroclypeus* and *Heterostegina*.

Cotypes.—U.S.N.M. nos. 497855–497858.

Occurrence.—Fairly common in the Guayabal (Tempoal of ver Wiebe and Muir), Claiborne Eocene. Cotypes selected from an outcrop 11 kilometers southeast of Sabaneta, Veracruz; collection of Dr. H. Jenny no. 1573.

This species is named in memory of the late Dr. Hans Jenny, who spent many years carrying out pioneer work in Mexican stratigraphy and collected the types of this and numerous other new species of larger Foraminifera.

OPERCULINOIDES OCALANUS (Cushman)

PLATE 12, FIGURE 5; PLATE 15, FIGURE 5

1921. *Operculina ocalana* CUSHMAN, U. S. Geol. Surv. Prof. Paper 128–E, p. 129, pl. 19, figs. 4, 5.

1935. *Operculina ocalana* CUSHMAN, referred to new genus *Operculinoides* by S. Hanzawa, Sci. Rep. Tôhoku Imp. Univ., ser. 2 (Geol.), vol. 18, no. 1, p. 18.

1937. *Operculina ocalana* Cushman, VAUGHAN *in* Sheppard's "The Geology of South-Western Ecuador," pp. 158–159, figs. 113, 114.

Cushman's original description of *O. ocalanus* reads as follows:

> Test complanate, much compressed, composed of two to three coils, the last with 16 to 18 chambers; sutures raised, confluent in the center, somewhat rounded, the area between concave and smooth; chambers three to four times as long as wide; central area of the test umbonate; periphery somewhat raised by a thickening in which the raised sutures terminate. Length as much as 6 millimeters.
>
> Geologic occurrence, Ocala limestone and Jackson formation.

Specimens from Ecuador are considered by Vaughan to differ in no essential particulars but are generally of smaller size. Specimens from Mexico agree well with the general description of Cushman and the later figures of Vaughan but, like the Ecuadorian specimens, are consistently smaller than the types. The following is a brief description:

Test complanate, much compressed, composed of 2 to 2½ whorls, the final whorl opening into a broad flange occupying the greater part of the test. Owing to bad state of preservation no ornament can be seen, the surface being worn smooth in all specimens found; there is evidence of the presence of an umbo at the center of the test, though not so marked as in typical specimens of *O. ocalanus*. Diameter, up to 3.0 mm (broken); thickness, 0.5 mm. Sections show 12 to 14 chambers in the final whorl, chambers long and narrow and the septa curved throughout, more strongly so as they approach the periphery. As in typical *O. ocalanus* the septa are somewhat raised and there is a strong tendency toward thickening at the periphery.

If we take into account the fact that all the specimens examined were incomplete, the slight differences in size, number of whorls, and number of chambers in the final whorl may be neglected, especially as the proportional development is almost identical with typical specimens of *O. ocalanus* from Ocala limestone.

Plesiotypes.—U.S.N.M. nos. 497859 and 497860.

Occurrence.—In Mexico the species occurs in the Tantoyuca formation, which is considered to belong to the Jackson Eocene. A larger species, very closely allied to *O. ocalanus*, and for a long time confused with that species, occurs in the Claiborne. This has now been referred to a new species, *Operculinoides jennyi*.

OPERCULINOIDES OCALANUS (Cushman) MINOR, new variety

PLATE 12, FIGURE 4; PLATE 15, FIGURES 1, 2; PLATE 21, FIGURE 3

A number of specimens of a small species of *Operculinoides* have been sectioned and are referred to a variety of *O. ocalanus* (Cushman), though perhaps the differences from that species are sufficient to warrant specific distinction. The test is much smaller but shows a similar umbonate form, with raised septa, the septa showing coarser beading or granulation than is customary in *O. ocalanus*.

Sections show the test to consist of 2½ whorls, with 15 or 16 chambers in the final whorl. The chambers are long and narrow, the sutures gently and regularly curved, but showing in general a rather more pronounced "angle" near the periphery than *O. ocalanus*, as may be seen from the figures (pl. 15, figs. 1, 2). Diameter, 2.1 to 2.5 mm; thickness, 0.4 mm.

Cotypes.—U.S.N.M. nos. 497861 and 497862.

Occurrence.—This form occurs rarely in the Guayabal formation (Tempoal of ver Wiebe and Muir, Claiborne) near the town of Tantoyuca, Veracruz. The cotypes were obtained from a locality east of Tempoal, Veracruz; collection of Dr. P. von Schumacher no. 2589.

OPERCULINOIDES VICKSBURGENSIS Vaughan and Cole

PLATE 12, FIGURE 6; PLATE 18, FIGURE 2; PLATE 19, FIGURES 8, 9

1936. *Operculinoides vicksburgensis* VAUGHAN and COLE, Proc. U. S. Nat. Mus., vol. 83, p. 490, pl. 36 (Byram Marl, Vicksburg, Miss.).

Description of Mexican specimens is as follows: Test small to medium size, compressed lenticular, completely involute, periphery rather thick and rounded. The sutures as seen on the exterior are clear lines of shell material, flush with the surface, and slightly sigmoid in shape. The most important feature in the external appearance is the presence of thin lines of clear shell material similar to the subdivision into chamberlets shown by *Heterostegina;* these disappear on sectioning, however, or merely show as thin transparent lines in the shell wall. This character was also seen to be well developed in specimens identified by the writer as *O. vicksburgensis* from the Byram marl of Byram, Miss. (see pl. 19, figs. 8, 9). Diameter, 2.0 to 3.0, average approximately 2.5 mm (compare 1.3 to 3.1 mm for *O. vicksburgensis*).

Sections show the presence of 3 to 3¼ whorls, with 18 to 24 chambers in the last whorl. This compares closely with 3½ to 4 whorls, with 18 to 26 chambers in the final whorl in *O. vicksburgensis.* The septa are straight for two-thirds of their length, then recurve regularly and rather abruptly toward the periphery.

Plesiotypes.—U.S.N.M. no. 497863.

Occurrence.—Alazan formation (Huasteca formation of Muir), lower Oligocene. (Occurs generally in association with *O. muiri.*)

Note.—There is clearly an error in the footnote given by Thiadens (1937, p. 97), referring his *Camerina* sp. C to this species, since the former, in my opinion, is either *Planularia* or *Cristellaria* (see Thiadens's pl. 15, fig. 4).

OPERCULINOIDES OLIVERI (Cushman)

PLATE 11, FIGURE 1; PLATE 15, FIGURE 3

1925. *Operculina oliveri* CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 9, p. 298, pl. 6, figs. 1, 2 (Guayabal, Rio Moctezuma, Mexico).

1927. *Operculina cushmani* COLE, Bull. Amer. Pal., vol. 14, no. 51, p. 23, pl. 2, fig. 14 (Guayabal type locality, Guayabal, Mexico).

Test large, involute, very thin, and complanate. From the exterior the test is seen to consist of a rapidly opening spiral, the septa showing as raised ribs, recurved strongly toward the periphery. There is at times a tendency toward beading on the septa, this being usually more strongly developed toward the center of the test. Diameter, up to 8.0 mm, averaging 4.0 mm.

Sections show the presence of 2 to 3 whorls, with 16 to 28 chambers in the final whorl. This large range is due to the inclusion of

incomplete or immature specimens, adult tests showing generally 24 to 28 chambers in the last whorl. The chambers are long and narrow, the length being about five times the width, the septa thin and regularly curved throughout.

Cole's *O. cushmani* is considered to be the same as Cushman's *O. oliveri* after careful comparison of topotype material of both species (from the Guayabal of the Guayabal type locality and the Moctezuma River, respectively), although it is possible that Cole also included in his species forms referred by the writer to *Operculinoides vaughani* (Cushman), q. v.

O. oliveri is considered to be intermediate between *O. cookei* (Cushman) and *O. vaughani* (Cushman) and may perhaps be ancestral to both. These species have all been referred to *Operculinoides* by Hanzawa, and the involute nature of *O. oliveri* and *O. vaughani* is clearly seen on plate 11, figures 1–3, of the present account.

Plesiotypes.—U.S.N.M. nos. 497864 and 497865.

Occurrence.—So far as is known, restricted to the Guayabal (Tempoal of ver Wiebe and Muir, Claiborne).

OPERCULINOIDES VAUGHANI (Cushman)

PLATE 11, FIGURES 2, 3

1921. *Operculina vaughani* CUSHMAN, U. S. Geol. Surv. Prof. Paper 128–E, p. 128, pl. 19, figs. 6–7.

1933. *Operculina oliveri* ELLISOR, *non* Cole, Bull. Amer. Assoc. Petr. Geol., vol. 17, p. 1299, pl. 2, fig. 15.

1935. *Operculina vaughani* Cushman, GRAVELL and HANNA, Journ. Pal., vol. 9, p. 334, pl. 29, figs. 6, 9, 12, 16–21.

As this species has been well described recently by Gravell and Hanna, and specimens so identified in the Mexican material are rare, it is not considered necessary to give here a detailed description. The species differs from *O. oliveri* (Cushman) in being of smaller size, rather more tightly coiled, and narrower and more numerous chambers and in having more regularly beaded sutures. In Mexico it occurs rather high in the Claiborne and is much less frequent than *O. oliveri.* The best specimens have been found in the Guayabal (Tempoal), Claiborne Eocene, of the Guayabal type locality of Cole; it also has been observed in the Guayabal exposed in the neighborhood of Tantoyuca, Veracruz.

OPERCULINOIDES TUBERCULATUS (Vaughan and Cole)

PLATE 14, FIGURES 3, 5; PLATE 20, FIGURES 9, 11

1936. *Operculina tuberculata* VAUGHAN and COLE, Proc. U. S. Nat. Mus., vol. 83, p. 488, pl. 35, figs. 1–4.

The following description, though to some extent a repetition of that of Vaughan and Cole, is based on a larger collection of material, including specimens from near Tempoal, Veracruz, and from near Tantoyuca, Veracruz.

Test small, flattened, very thin, involute, septa raised, somewhat limbate, and broken up into large tubercles. The poles of the test also show a group of tubercles, or a large central tubercle surrounded by small beads. A well-developed keel gives the test a rather truncated periphery. Diameter, up to 2.0 mm, average 1.8 mm.

Sections show regular, rather open coiling, with 2½ to 3 whorls, with 15 to 20 chambers in the final whorl. The septa are thin and nearly straight for one-half to two-thirds of their length, then gently curved toward the periphery. Chambers not very numerous, with a rather rectangular appearance.

This species was long considered to be a variety of *O. mariannensis* Vaughan (1928), from which it differs principally in the possession of a greater number of chambers, a thicker test and generally more robust form, but it is considered by Vaughan and Cole to rank as a distinct species. In spite of the thinness of the test and the clear marking of all whorls on the exterior, I believe that this species should be referred to *Operculinoides*. This is supported by Hanzawa's placing the closely allied *O. mariannensis* in that genus and by the involute nature of the test shown by the transverse sections figured by Vaughan and Cole (1936, pl. 35, figs. 3, 3a, and 4). My preparations also show this involute character.

Plesiotypes.—U.S.N.M. nos. 497866, 499868, and 497869.

Other specimens.—U.S.N.M. no. 497867.

Occurrence.—Tantoyuca formation, Jackson Eocene.

OPERCULINOIDES CATENULA (Cushman and Jarvis)

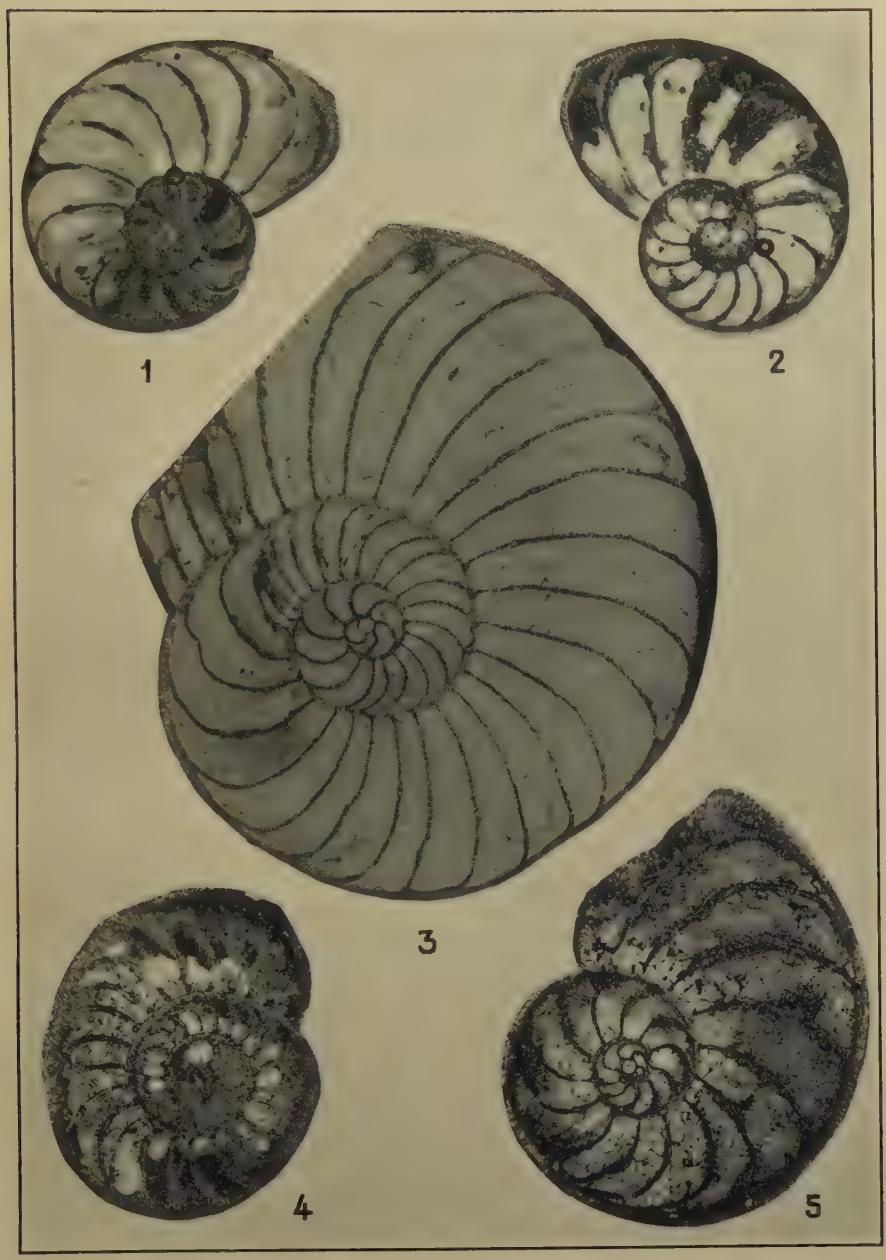
PLATE 14, FIGURES 6, 8; PLATE 18, FIGURE 5; PLATE 21, FIGURES 7, 8

1932. *Operculina catenula* CUSHMAN and JARVIS, Proc. U. S. Nat. Mus., vol. 80, art. 14, p. 42, pl. 12, figs. 13a–b.

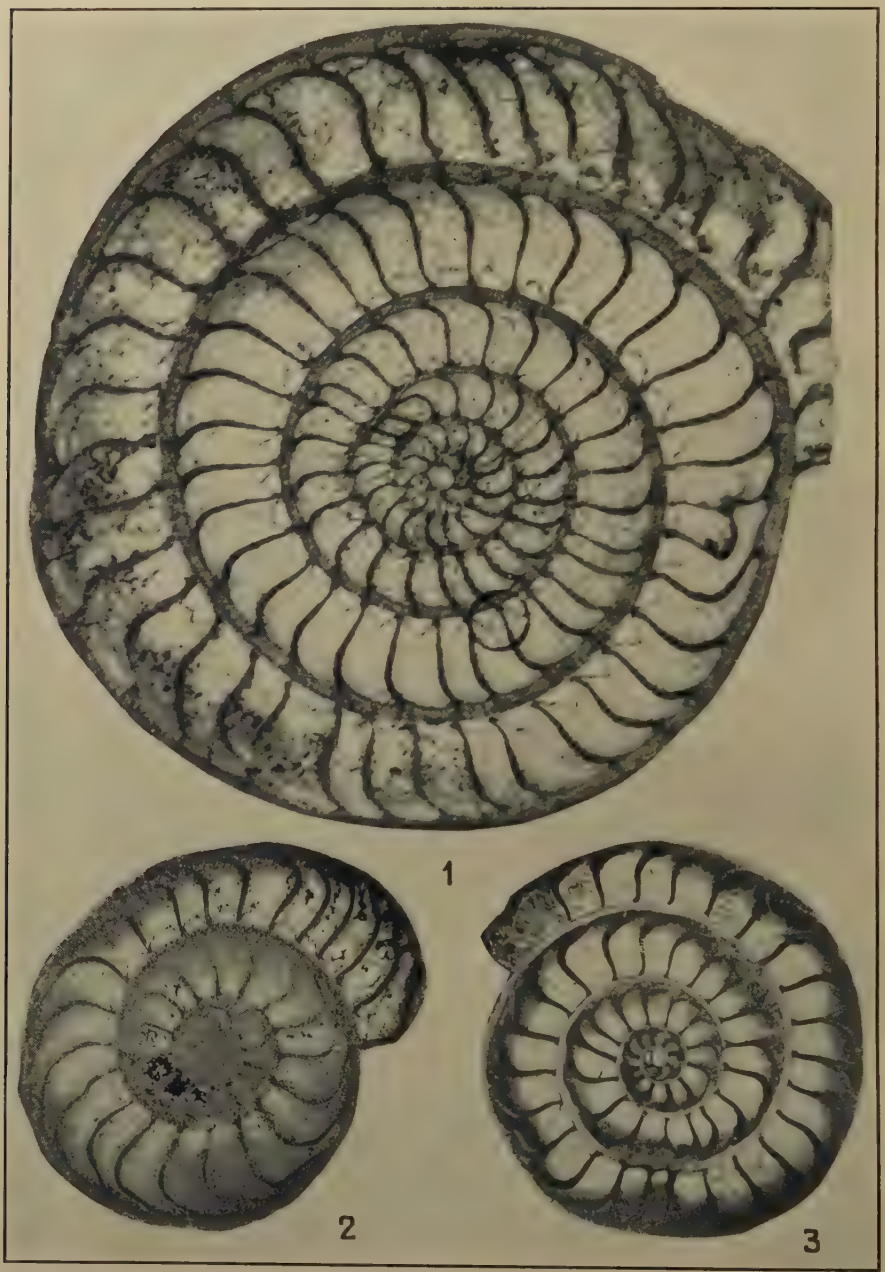
Description of Mexican specimens ascribed to this species is as follows:

Test small to medium in size, compressed lenticular, completely involute, with a strongly developed rounded keel. The sutures (on rather weathered specimens) show as raised radiating ribs, irregularly beaded, with a strong umbonal boss. Diameter, up to 3.0 mm (average 2.5 mm for 5 specimens); thickness, 0.7 to 0.85 mm (cf. diameter 2.25 mm, thickness 0.6 mm for *O. catenula*).

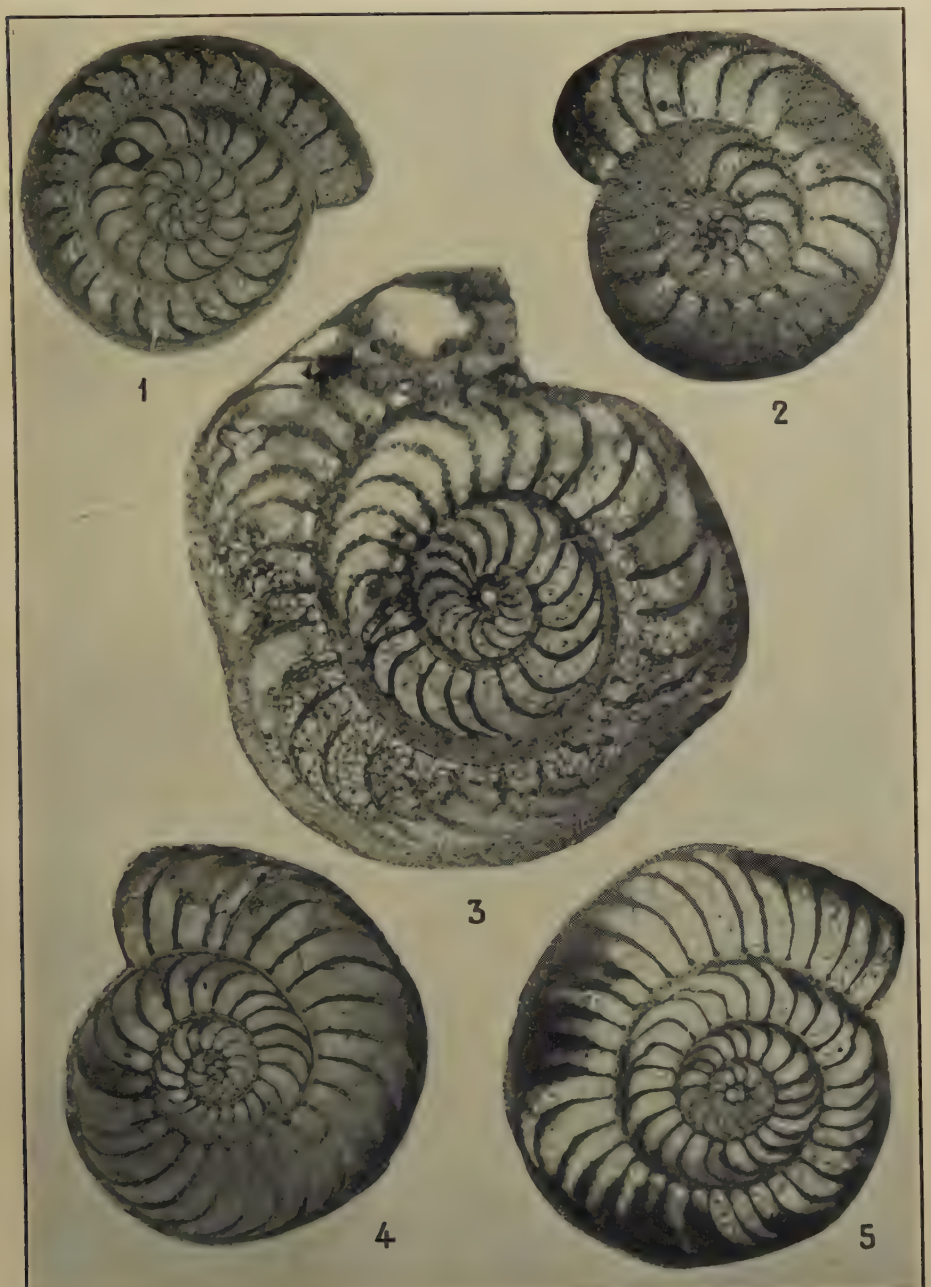
Sections show a rather loosely coiled test of 2 to 2¼ whorls with 17 to 22 chambers in the final whorl (compare 15 chambers in the



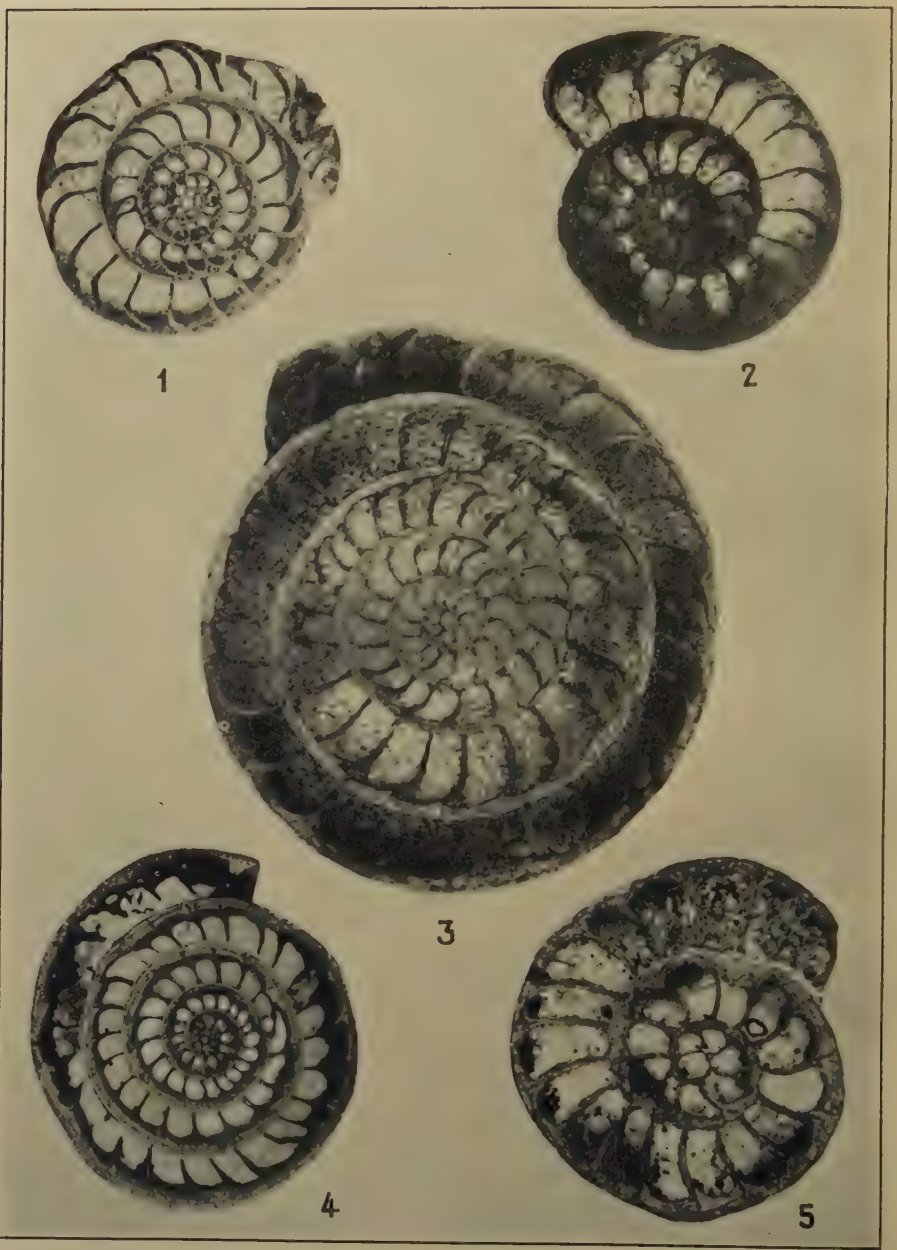
1, 2, *Operculinoides ocalanus* (Cushman) *minor*, new variety, Guayabal formation (Tempoal of ver Wiebe and Muir), collection P. von Schumacher no. 2589, east of Tempoal, Veracruz; 3, *O. oliveri* (Cushman), Guayabal formation, topotype material from Romance, Rio Moctezuma; 4, *Operculinoides* sp. A, Tantoyuca formation, collection P. von Schumacher no. 1624, east of Tempoal; 5, *O. ocalanus* (Cushman), Tantoyuca formation, collection K. T. Goldschmid Pit. no. 283, southeast of Tempoal. ×20.



1, *Operculinoides willcoxii* (Heilprin), Tantoyuca formation, near Tantoyuca, Veracruz (Tantoyuca type locality); 2, *O. tuxpanensis* (Thalmann), Tuxpam formation, lower Miocene, near Tuxpam, Veracruz; 3, *O. antiguensis* Vaughan and Cole, Meson formation, near Bustos, Veracruz (Bustos Well no. 1). ×20.



1, *Operculinoides antiguensis* Vaughan and Cole, Meson formation, Bustos Well no. 1, near Bustos, Veracruz; 2, *O. tuxpanensis* (Thalmann), Tuxpam formation, near Tuxpam, Veracruz; 3, *O. jennyi*, new species, Guayabal formation, near Sabaneta, Veracruz, collection H. Jenny no. 1573; 4, *O. prenummulitiformis*, new species, Guayabal formation, well sample, Poza Rica no. 8; 5, *O. nummulitiformis* (Rutten), Tantoyuca formation, collection P. von Schumacher no. 2412, east of Tempoal, Veracruz. ×20.



1, *Operculinoides palmarealensis*, new species, Alazan formation (Huasteca of Muir), Mecatepec Well no. 5; 2, *O. vicksburgensis* Vaughan and Cole, Alazan formation, collection E. Gevaerts no. 292, southern Miahuapam, Veracruz; 3, *Camerina vanderstoki* (Rutten and Vermunt), Guayabal formation, near Furbero, Veracruz, collection J. Clopton no. 21; 4, *C. guayabalensis*, new species, Guayabal (Tempoal of ver Wiebe and Muir), well sample, Poza Rica no. 8; 5, *Operculinoides catenula* (Cushman and Jarvis), lower part of Chicontepec formation, near Sabaneta, Veracruz, collection W. Tappolet no. 1848. ×20.

last whorl in *O. catenula*). The sutures are rather thick and gently curved, the keel showing as a thick outer shell wall along the periphery.

O. catenula was described by Cushman and Jarvis from beds in Trinidad regarded as Upper Cretaceous, showing many species in common with the Velasco of Mexico. There seems little doubt that the Mexican species should be referred to *O. catenula*, or, if not to that species, to a variety, but the original description and figures are inadequate for exact determination of the original species and comparative material was unfortunately not available for study. It has been placed in *Operculinoides* on account of the involute nature and the rather loose coiling. In some respects it is not unlike *Pellatispirella* but lacks the special features of the aperture and construction of the shell wall of that species.

Plesiotypes.—U.S.N.M. nos. 497870 and 497871.

Occurrence.—In Mexico the species occurs in beds of doubtful age, which may perhaps be referable to the Chicontepec (probably Tanlajas formation of Muir).

OPERCULINOIDES species A

PLATE 15, FIGURE 4; PLATE 21, FIGURE 6

Test small, compressed, completely involute. Ornamentation, if present, is completely obscured by the bad state of preservation. Diameter, 2.2 mm (average); thickness, 0.5 mm. Sections show 2¼ to 2½ whorls, with 21 to 23 chambers in the final whorl. The septa are rather thick and regularly curved throughout their length.

In many respects this species is similar to *Operculinoides advenus* Vaughan and Cole, which has not been observed in the collections examined. It differs from the latter, however, in having fewer coils and being in general a smaller form. On account of the small amount of material available, it has been thought inadvisable to give a specific denomination at the present time.

Cotypes.—U.S.N.M. nos. 497872 and 497873.

Occurrence.—Rare in the Tantoyuca formation, Jackson Eocene. The above description is based on specimens obtained east of Tempoal, Veracruz; collection of Dr. P. von Schumacher no. 1624.

OPERCULINOIDES species B

PLATE 12, FIGURE 3; PLATE 20, FIGURE 7; PLATE 21, FIGURE 5

Test small, compressed lenticular, completely involute, surface smooth, without ornamentation, septa showing as lines of clear shell material. A number of small, regularly spaced tubercles occur between the septa, in a line parallel to and near the periphery (see

pl. 12, fig. 3); these may appear only on weathering and are of value in distinguishing this species from other closely similar small species. Diameter, average 2.0 mm; thickness, 0.5 mm.

Sections show the test to be close-coiled, consisting of 4 to 5 whorls, with 22 to 24 chambers in the final whorl. The septa are of moderate thickness, oblique and gently curved, the chambers being only slightly longer than wide. Owing to the rarity of the species in the collections examined the material is considered insufficient for the erection of a new species.

Cotypes.—U.S.N.M. nos. 497874, 497875, 497876, and 497877.

Occurrence.—Guayabal (ver Wiebe's Tempoal), Claiborne Eocene; rare. The description is based on specimens from the Tantoyuca region, Veracruz; collection of H. E. Rankin no. 277.

? OPERCULINOIDES species

PLATE 20, FIGURE 6; PLATE 21, FIGURE 4

Test small, compressed lenticular, sharply keeled, and completely involute. The sutures are nearly straight, radiating, and show a slight tendency to become beaded toward the center. The appearance is similar to flattened specimens of *Camerina jacksonensis* Gravell and Hanna. Diameter (for 10 specimens), 1.3 mm; thickness, 0.3 to 0.4 mm.

Sections show a test of 3 to 3½ whorls, with 11 to 13 chambers in the final whorl. The septa are oblique and only slightly curved, the chambers being slightly greater in width than in length. From the scarcity and bad state of preservation of the material it is difficult to say whether the species should be referred to *Camerina* or *Operculinoides*, and for these reasons it is considered unwise to give a name to the species until more and better preserved material is available for further study.

Cotypes.—U.S.N.M. nos. 497878 and 497879.

Occurrence.—Very rare in the Tantoyuca formation, Jackson Eocene. The description is based on specimens from near Los Ajos, Hacienda Santa Clara, southeast of Tantoyuca, Veracruz; collection of Dr. H. Meyer no. 1471.

Genus CAMERINA Bruguière, 1792

CAMERINA VANDERSTOKI (Rutten and Vermunt)

PLATE 13, FIGURE 7; PLATE 18, FIGURE 3; PLATE 22, FIGURES 10–12

1932. *Nummulites vanderstoki* RUTTEN and VERMUNT, Proc. Sect. Sci. Kon. Akad. Wetensch. Amsterdam, vol. 35, p. 240, pl. 1, fig. 8; pl. 2, figs. 6, 12.

One of the commoner forms of *Camerina* found in Mexico has been referred to *C. vanderstoki*, after careful comparison with the fig-

ures and description of that species, and although it occurs at a lower horizon in Mexico (Claiborne) than in Curaçao (Jackson) it is considered to be at most only a minor variant of Rutten and Vermunt's species. As the stratigraphy of the various West Indian islands is in a somewhat chaotic state, there may perhaps be an error in the horizon ascribed to *N. vanderstoki* in Curaçao.

Description of the Mexican specimens is as follows: Test small to medium in size, flattened lenticular, completely involute, sutures rather obscure owing to state of preservation, radiate, may be slightly raised (due to weathering?), with a tendency to form beads of clear shell material in the umbonal region. Diameter, up to 4.5 mm, average 3.5 mm; average thickness, 1.2 mm (1.1 to 1.3 mm for 7 specimens).

Sections show 4½ to 5½ whorls, with 27 to 30 chambers in the final whorl. The septa are regular, nearly straight for a little more than half their length, then evenly recurved toward the periphery. The chambers are rather longer in proportion to their width than in the smaller, somewhat similar species, *Camerina guayabalensis*. Below are given figures for comparison of material from Mexico with the type from Curaçao:

Species	Diameter	Thickness	Number of of whorls	Chambers in final whorl
	Mm	*Mm*		
Camerina vanderstoki Mexican specimens	3.5	1.2	4.5–5	27–30
Nummulites vanderstoki Rutten and Vermunt (from Curaçao)	3.0	1.2–1.25	4.5–5	18–24

Plesiotypes.—U.S.N.M. nos. 497880, 497881, and 497882.
Other specimens.—U.S.N.M. nos. 497883 and 497884.

CAMERINA MOODYBRANCHENSIS Gravell and Hanna

PLATE 13, FIGURE 5; PLATE 20, FIGURE 2; PLATE 22, FIGURE 2

1935. *Camerina moodybranchensis* GRAVELL and HANNA, Journ. Pal., vol. 9, p. 332; pl. 29, figs. 15, 22–24.

This species has been well described and figured already by Gravell and Hanna, so only a few notes will be given on Mexican specimens ascribed to this species.

Test small to medium in size, compressed lenticular, completely involute. The septa are not raised and show as nearly straight radiating lines of clear shell material. Diameter, average 2.5 mm; thickness, 0.7 to 0.8 mm.

Sections show a rather tightly coiled test of 4 to 5 whorls with 25 to 30 chambers in the final whorl. The septa are gently curved and only very slightly oblique. A comparison of the dimensions and

the accompanying figures with those given by Gravell and Hanna shows only slight divergences, and this is supported by comparison of Mexican specimens with material identified as *C. moodybranchensis* from a well core in Montgomery County, Tex.

Plesiotypes.—U.S.N.M. nos. 497885, 497887, and 497888.

Other specimens.—U.S.N.M. no. 497886.

Occurrence.—Tantoyuca formation, Jackson Eocene, in Tantoyuca area.

CAMERINA JACKSONENSIS Gravell and Hanna

PLATE 13, FIGURE 6; PLATE 20, FIGURE 8; PLATE 22, FIGURE 9

1935. *Camerina jacksonensis* GRAVELL and HANNA, Journ. Pal., vol. 9, p. 331; pl. 29, figs. 1–5, 7–8, 10–11, 13–14.

Mexican specimens identified as *C. jacksonensis* may be described as follows:

Test small, lenticular, completely involute. The septa are of clear shell material, radiating, straight to slightly curved, and generally obscurely beaded toward the umbonal region, where there is a mass of clear shell material of varying extent. Diameter (average for 10 specimens), 1.6 mm; thickness, average 0.6 mm.

Sections show a regularly coiled test of 4 to 4½ whorls with 15 to 19 chambers in the final whorl. The septa are oblique and show a gentle, even curvature. The spacing of the septa appears to be somewhat variable, some specimens showing open spacing with chambers nearly as wide as long (see pl. 20, fig. 8) and others a much closer spacing with chambers correspondingly more elongate. Typical specimens, as figured by Gravell and Hanna, show stronger beading than is usually shown by the Mexican material, but this is considered to be insignificant.

Plesiotypes.—U.S.N.M. nos. 497889 and 497890.

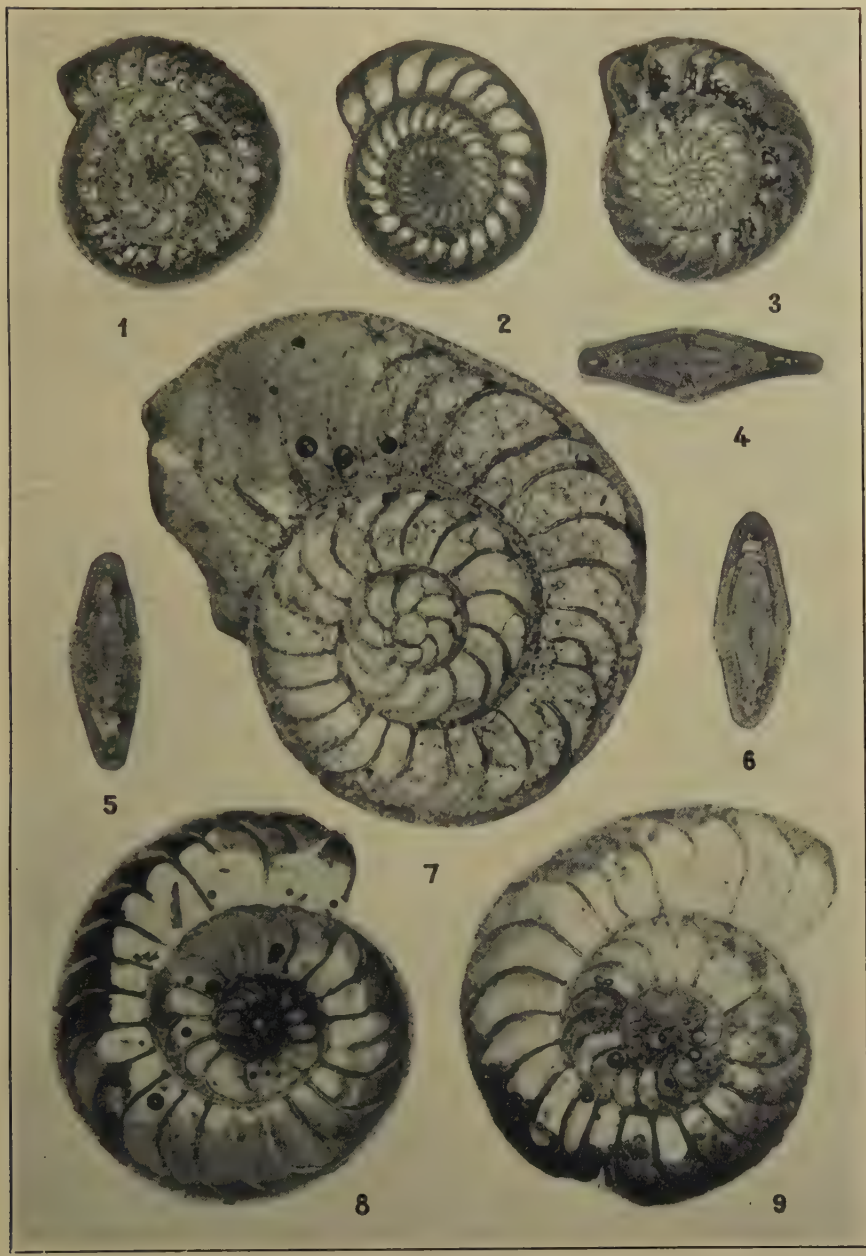
Occurrence.—Occurs fairly abundantly in the lower part of the Tantoyuca formation, Jackson Eocene.

CAMERINA JACKSONENSIS GLOBOSA new variety

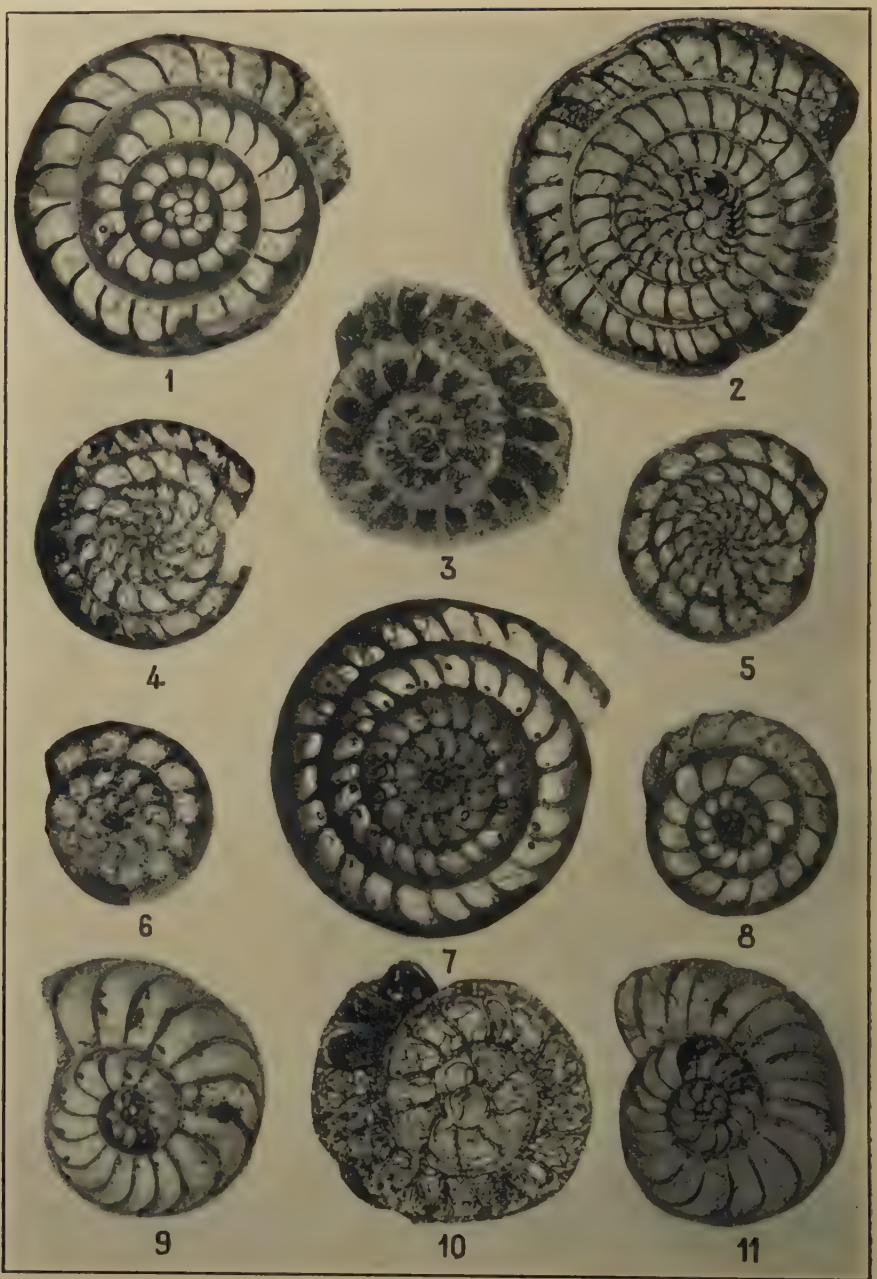
PLATE 13, FIGURES 1, 2; PLATE 20, FIGURES 4, 5; PLATE 22, FIGURES 5, 6

Test small, stoutly lenticular to subglobose, completely involute, with sharply keeled periphery. The sutures are seen to be radiate and may be raised into ribs, which tend to be beaded to a variable extent, especially toward the center, where they frequently coalesce into a boss of clear shell material. Diameter, up to 2.0 mm (average 1.7 mm); thickness, average 0.9 mm.

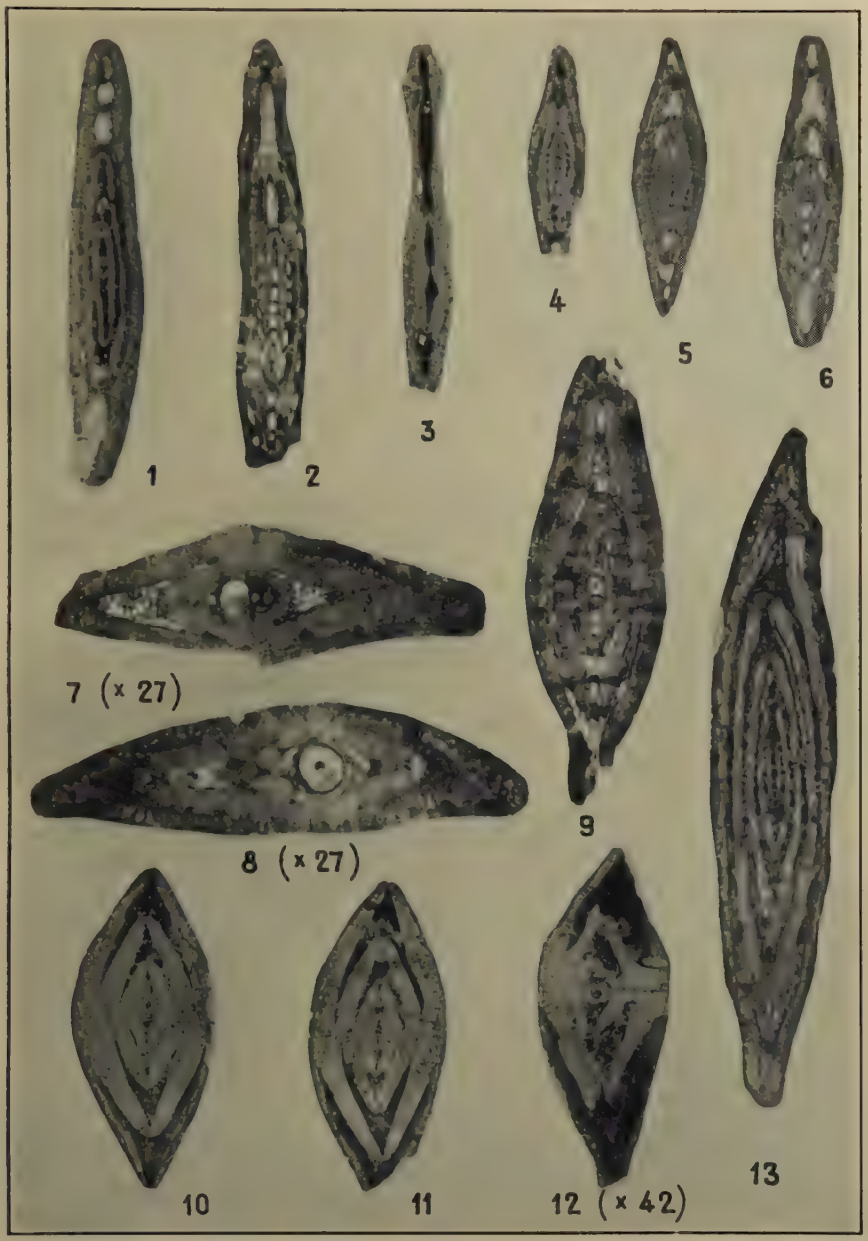
Sections show the test to be rather tightly coiled, consisting of 4½ to 5 whorls, with 15 to 17 chambers in the final whorl. The septa are oblique and gently curved throughout their length.



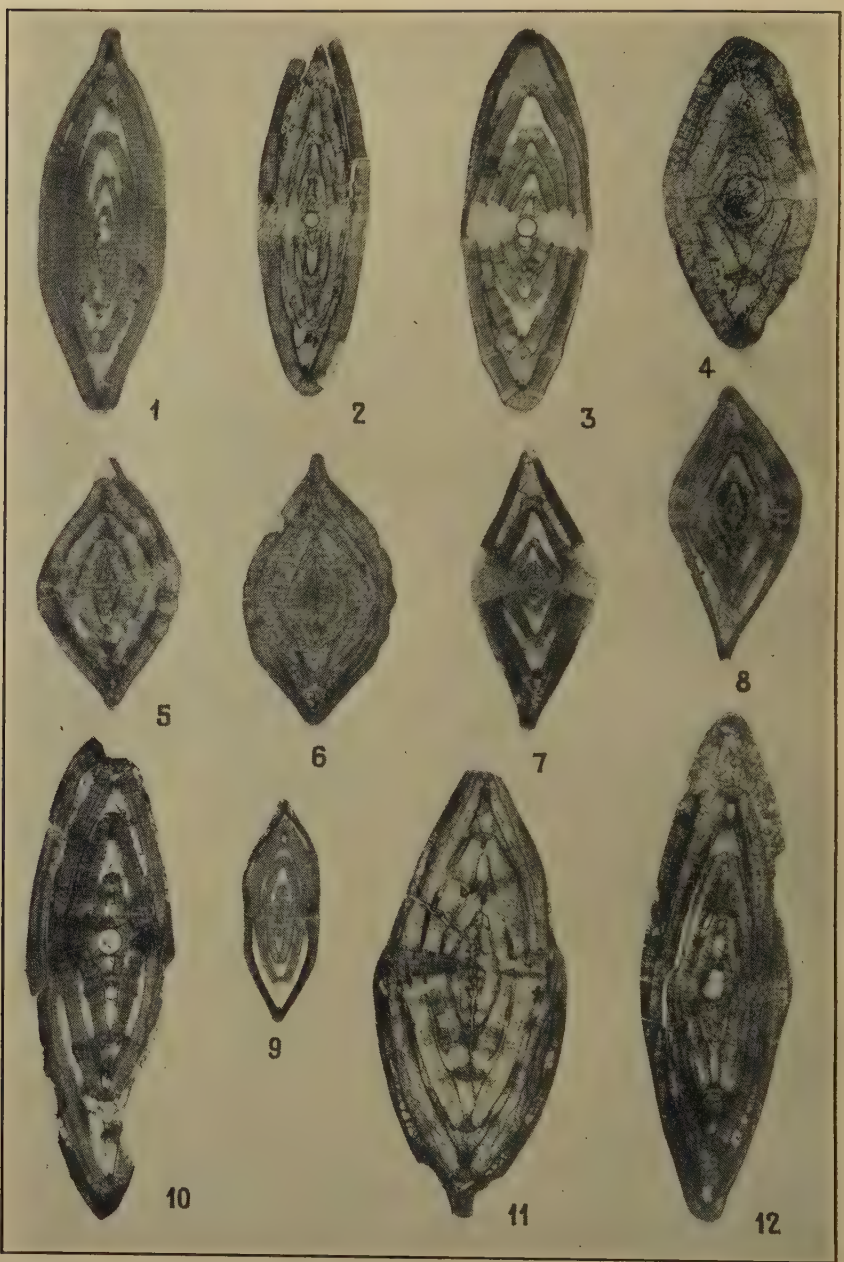
1–6, *Operculinoides semmesi* Vaughan and Cole, Meson formation, near Potrero del Llano, Veracruz; 7, *O. jennyi* new species, Guayabal formation (Tempoal of ver Wiebe and Muir), near Sabaneta, Veracruz, collection H. Jenny no. 1573; 8, 9, *O. vicksburgensis* Vaughan and Cole, specimens from Byram, Miss., for comparison with Mexican specimens. ×20.



1, *Operculinoides muiri*, new species, Alazan formation (Huasteca of Muir), collection E. Gevaerts no. 269, southern Miahuapam, Veracruz; 2, *Camerina moodybranchensis* Gravell and Hanna, Tantoyuca, well sample, Poza Rica no. 7; 3, ?*C. dickersoni* Palmer, Cardenas beds (Upper Cretaceous), near Cardenas, San Luis Potosi, ×42; 4, 5, *C. jacksonensis* Gravell and Hanna *globosa*, new variety, Tantoyuca formation, near Tantoyuca, Veracruz, collection W. H. Hegwein no. 2483; 6, ?*Operculinoides* sp., Tantoyuca formation, collection H. Meyer no. 1471, near Los Ajos, Santa Clara, southeast of Tantoyuca; 7, *Operculinoides* sp. B, Guayabal formation (Tempoal of Muir and ver Wiebe), collection H. Rankin no. 277, Tantoyuca region; 8, *Camerina jacksonensis* Gravell and Hanna, Tantoyuca formation, Tantoyuca type locality, near Tantoyuca; 9, 11, *Operculinoides tuberculatus* (Vaughan and Cole), Tantoyuca formation, collection W. H. Hegwein no. 1559, Tantoyuca region; 10, *Camerina pellatispiroides*, new species, El Cristo Well no. 1. All figures except fig. 3 ×20.



1, *Operculinoides nummulitiformis* (Rutten), Tantoyuca formation, collection P. von Schumacher no. 2412, east of Tempoal, Veracruz; 2, *O. prenummulitiformis*, new species, Guayabal formation, well sample, Poza Rica no. 8; 3, *O. ocalanus* (Cushman) *minor*, new variety, Guayabal formation, collection P. von Schumacher no. 2589, east of Tempoal; 4, *?Operculinoides* sp., Tantoyuca formation, collection H. Meyer no. 1471, near Los Ajos, Santa Clara, southeast of Tantoyuca: 5, *Operculinoides* sp. B, Guayabal formation, collection H. E. Rankin no. 277, near Tantoyuca; 6, *Operculinoides* sp. A, Tantoyuca formation, collection P. von Schumacher no. 1624, east of Tempoal; 7, 8, *O. catenula* (Cushman and Jarvis), lower part of Chicontepec formation, near Sabaneta, collection W. Tappolet no. 1848, ×27; 9, *O. jennyi*, new species, Guayabal formation (Temporal of ver Wiebe and Muir), near Sabaneta, collection H. Jenny no. 1573; 10, 11, *O. antiguensis* Vaughan and Cole, Meson formation, bluff below Tampico Country Club, Tampico, Tamaulipas; 12, *?C. dickersoni* Palmer, Cardenas beds (Upper Cretaceous), Cardenas, San Luis Potosi, ×42; 13, *O. willcoxii* (Heilprin), Tantoyuca type locality, near Tantoyuca on road to Chopopo, Veracruz. All figures except figs. 7, 8, and 12 ×20.



1, *Operculinoides muiri*, new species, Alazan formation (Huasteca of Muir), collection E. Gevaerts no. 269, southern Miahuapam, Veracruz; 2, *Camerina moodybranchensis* Gravell and Hanna, Tantoyuca formation, well sample, Poza Rica no. 7; 3, *C. guayabalensis*, new species, Guayabal formation (Tempoal of ver Wiebe and Muir), well sample, Poza Rica no. 8; 4, *C. pellatispiroides*, new species, lower part of Chicontepec formation, El Cristo Well no. 1, Veracruz; 5, 6, *C. jacksonensis* Gravell and Hanna *globosa*, new variety, Tantoyuca formation, collection W. H. Hegwein no. 1503, near Tantoyuca; 7, 8, *Operculinoides palmarealensis*, new species, Alazan formation (Huasteca of Muir), Mecatepec Well no. 5, Veracruz; 9, *C. jacksonensis* Gravell and Hanna, Tantoyuca formation, Tantoyuca type locality, Tantoyuca-Chopopo road, Veracruz; 10–12, *Camerina vanderstoki* (Rutten and Vermunt), Guayabal formation, near Tempoal, Veracruz, collection A. T. Nolthenius no. 157. ×20.

The principal difference from typical *C. jacksonensis* lies in the more globose form of the test, as is indicated by the varietal name. This is clearly shown by the transverse sections figured.

Cotypes.—U.S.N.M. nos. 497891, 497894–497896.

Other specimens.—U.S.N.M. nos. 497892 and 497893.

Occurrence.—The variety occurs in the Tantoyuca formation, Jackson Eocene, possessing a similar range and distribution to the typical form.

CAMERINA GUAYABALENSIS, new species

PLATE 13, FIGURE 4; PLATE 18, FIGURE 4; PLATE 22, FIGURE 3

Test small to medium in size, compressed globose-lenticular, and completely involute. The strongly developed rounded keel of clear shell material gives a somewhat truncated appearance to the periphery. Septa nearly straight, anastomosing to a variable extent at the poles of the test, where there may be developed a small mass of clear shell material. Diameter averages 2.8 mm, with a maximum observed of 3.5 mm; average thickness, 0.85 to 0.95 mm.

Median sections show regular coiling with a thick outer wall (forming the keel mentioned above). The chambers are typically camerinid in character, being nearly as wide as long, with nearly straight septa, slightly oblique and joining the periphery in a gentle curve. There are 4½ to 5 whorls, with 24 to 27 chambers in the final whorl. The canal system is typically that of *Camerina.*

This species is in many respects similar to *C. vanderstoki* (Rutten and Vermunt), both in exterior and in section, but the latter is generally larger and thicker, does not show such a heavily developed keel (with truncation of the periphery), and in section shows more chambers in the final whorl (28 to 30 chambers in *C. vanderstoki* compared with 24 to 27 in *C. guayabalensis*).

Cotypes.—U.S.N.M. nos. 497897 and 497898.

Occurrence.—In the Guayabal (Tempoal of ver Wiebe and Muir) this species is of fairly frequent occurrence, in association as a rule with *Eulinderina guayabalensis* (Nuttall) and *Operculinoides prenummulitiformis.* Cotypes have been selected from Mecatepec Well no. 5 and Poza Rica Well no. 8, Veracruz, the latter material giving superior results on sectioning.

CAMERINA PELLATISPIROIDES, new species

PLATE 20, FIGURE 10; PLATE 22, FIGURE 4

While investigating samples from El Cristo Well no. 1 with a view to obtaining topotype material of *Discocyclina cristensis* (Vaughan) and *Actinosiphon semmesi* Vaughan, I found several specimens of a small globose camerinid. On sectioning, the species

was seen to differ very considerably from any other Mexican form examined, being similar in some respects to *Camerina wadiai* (L. M. Davies, 1927, p. 273, pl. 21, figs. 17, 18; pl. 22, figs. 7–9), from the Eocene of India. With the recent appearance of Hanzawa's (1937) paper on *Pellatispirella* it was seen to show close affinities with that genus, and for a time was thought to be allied to *P. antillea* Hanzawa. Detailed sectioning shows, however, that though measurements agree well with that species, the apertural characters are those of *Operculina* and *Camerina*, and no evidence was found of the complex double shell wall characteristic of *Pellatispirella*. The canal system seems to be much simpler than is usual in *Camerina*, showing many similarities to *Pellatispirella*, and the species may be ancestral to that genus, thus giving some slight evidence for the inclusion of *Pellatispirella* in the Camerinidae.

A description of the new species is as follows: Test small, globosely lenticular, completely involute. The ornament is not discernible owing to the very poor state of preservation, with secondary crystallization on the exterior. Diameter, 1.5 to 2.0 mm; thickness, 1.0 mm.

Sections show the test to consist of 2 to 2½ whorls, with 7 or 8 chambers in the first whorl, 15 or 16 in the second whorl, and in the case of larger specimens (2½ whorls), 16 or 17 chambers in the final whorl. The initial chamber, which is spherical to subspherical in shape, measures 220μ to 270μ in diameter. The walls and septa are very thick, the latter being rather irregular and only slightly curved. The canal system consists of a well-developed marginal cord, as in *Rotalia*, with few branches (in distinction from the many branching marginal system in *Camerina*); strongly developed septal canals; vertical canals, especially in the umbonal region, are seen in transverse sections.

Cotypes.—U.S.N.M. no. 497899.

Occurrence.—Basal Eocene, in association with *Discocyclina cristensis* (Vaughan) and *Actinosiphon semmesi* Vaughan (probably Chicontepec, or the Tanlajas of Muir). Cotypes have been selected from samples from El Cristo Well no. 1, 3,785–3,790 feet.

?CAMERINA DICKERSONI Palmer

PLATE 20, FIGURE 3; PLATE 21, FIGURE 12

1934. *?Camerina dickersoni* PALMER, Mem. Soc. Cubana Hist. Nat., vol. 8, p. 243, figs. 4, 5, pl. 14, figs. 1, 2, 4, 6, 8.

Test very small, compressed lenticular, completely involute, with a well-developed keel of clear shell material. The septa are radiate, gently curved, terminating at the umbo in a rather large central boss. Diameter (average for 10 specimens), 1.0 mm; thickness, 0.3 to 0.45 mm.

Sections show 2½ to 2¾ whorls, with 17 to 20 chambers in the final whorl, but as the specimens are badly preserved it is possible that well-preserved adult specimens would show a slightly larger test with more chambers in the final whorl. The septa are seen to be thick, with well-marked canals giving the appearance of double shell walls. The general appearance in both median and transverse sections differs considerably from that of *Camerina*, there being closer resemblance to *Pellatispirella* as suggested by Hanzawa (1937, p. 115), though the sections fail to reveal the typical apertural characters and structure of the shell wall and canal-system of that genus. It is possible that this species, with *C. cubensis* Palmer and *C. vermunti* Thiadens, all occurring in the Upper Cretaceous, should be referred to a new genus, one of the principal features being the presence of a deep peripheral groove not seen in other species of Camerinidae.

The principal difference between *C. dickersoni* and *C. vermunti* (from study of Mexican specimens of the former) seems to be in the form of the septa, which are much thicker and more curved in the former species. Other characters are compared in the following table:

Species	Diameter	Thickness	Number of whorls	Number of chambers in final whorl
	Mm	*Mm*		
C. dickersoni Palmer	[1] 1.0	[1] 0.33	2.5	16
C. dickersoni Palmer (Mexican specimens)	[2] 1.0	0.3–0.45	2.5–2.75	17–20
C. vermunti Thiadens	1.0–1.5	0.4–0.7	3–3.5	19–23

[1] Cotype.
[2] Average.

It is seen that the Mexican specimens approximate very closely *C. dickersoni*, although the differences between the three species are not great.

Plesiotypes.—U.S.N.M. nos. 497901 and 497902.

Other specimens.—U.S.N.M. no. 497900.

Occurrence.—This species occurs in Mexico in the Upper Cretaceous Cárdenas beds exposed in the railroad cuttings near Cárdenas, San Luís Potosí, where it is associated with *Lepidorbitoides minima* Douvillé and *?Meandropsina rutteni* Palmer. This is a similar assemblage to that reported from Cuba, and to date the species has not been recorded from other localities in the Tampico Embayment.

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NOTE

Additional American species of *Operculina* and *Nummulites* (*Camerina*) have been described by F. M. Anderson (*N. carmenensis*, Proc. California Acad. Sci., ser. 4, vol. 17, no. 1, p. 26, pl. 1, figs. 23, 24, 1928); Katherine van Winkle Palmer (*N. costaricensis*, Bull. Amer. Pal., vol. 10, no. 40, p. 9, pl. 1, fig. 9, 1923); P. J. Pijpers (*O. bonairensis*, "Geology and Palaeontology of Bonaire (Dutch West Indies)," p. 56, pl. 1, figs. 32, 33, 1933); and Willard Berry (*O. atascaderensis*, *O. a. samanica*, *O. peruviana*, *O. samanica*, and *O. talara*, Eclogae geol. Helvetiae, vol. 23, 1930, and Journ. Washington Acad. Sci., vol. 22, 1932). These are not considered of sufficient importance in connection with the present studies to warrant their inclusion in the foregoing list of literature.

While the present account was awaiting publication two important additions were made to the literature of the American species of Camerinidae; namely, "The *Lepidocyclina texana* Horizon in the *Heterostegina* Zone, Upper Oligocene of Texas and Louisiana," by Donald W. Gravell and Marcus A. Hanna (Journ. Pal., vol. 11, pp. 517–529, pls. 60–65, 1937), in which two new species were described (*Operculinoides ellisorae* and *O. howei*), and "Stratigraphy and Micropaleontology of Two Deep Wells in Florida," by W. Storrs Cole (Florida Dept. Conserv. Geol. Bull. 16, pp. 1–73, pls. 1–12, 1938), referring to several American species of *Operculinoides*, with excellent figures. It is regretted that these publications were received too late for inclusion in the discussion of the Mexican species of *Operculinoides*. Reference should also be made to a recent paper by Donald W. Gravell and Marcus A. Hanna, entitled "Subsurface Tertiary Zones of Correlation through Mississippi, Alabama, and Florida" (Bull. Amer. Assoc. Petr. Geol., vol. 22, no. 8, pp. 984–1013, pls. 1–17, 1938), in which notes are given regarding the distribution and zonal value of a number of species of Camerinidae, and several species are figured.

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